mental vibrational energy from a vibration source **12** to electrical energy. The electrical energy may be received and stored in an energy store **14** (e.g., battery, a supercapacitor, etc) and utilized to power an electronic device (not shown). Alternatively, the energy harvester **10** may perform as a sensor to monitor the conditions of a dynamic system via the electrical energy. In addition, the energy harvester **10** may not include the energy store **14**, and may perform as an actuator by translating the electrical energy into a mechanical motion.

[0056] The energy harvester **10** includes a housing **16**, a transducer **18**, and an amplifier **20**. The transducer **18** and the amplifier **20** reside within the housing **16**. While the housing **16** is depicted as having a cylindrical shape, it is understood that the housing **16** may have another suitable shape, such as a cuboid, and is not limited to the cylindrical shape depicted.

[0057] The transducer **18** may include two parts which move relative to each other. For example, the transducer **18** may include a first part **22** and a second part **24** that are centered about a central axis **26**. The first part **22** and the second **24** slidingly move along the central axis **26** relative to each other. One part may be fixed to the housing **16** while the other part is moveable. Alternatively, both parts may be detached from the housing **16** and move relative to each other.

[0058] The transducer **18** may be an electromagnetic transducer having a series of magnets **28** and coils **30**. The magnets **28** and the coils **30** may be disposed within the second part **24** which is disposed within the first part **22**. The magnets **28** may be coupled to the first part **22** while the coils are coupled to the second part **24**. Accordingly, by way of the first part **22** and the second part **24**, the magnets **28** and the coils **30** move relative to each other along the central axis **26**. The magnets **28** and the coils **30** move relative to each other in response to kinetic energy from the vibration source **12**. The relative movement causes a variation in the electromagnetic field, thereby generating electrical potential across the coil **30** and the electrical signal. An example of an electromagnetic transducer is more fully described in co-pending patent application titled "ELECTROMAGNETIC ENERGY TRANSDUCER", the disclosure of which is incorporated by reference herein.

[0059] The transducer **18** can also be a piezoelectric transducer or other suitable transducers. More particularly, the energy harvester **10** can include a transducer that generates energy based on, for example, piezoelectric, electrostatic, magnetostrictive, and/or electrostrictive actuation. Thus the energy harvester **10** is not limited to an electromagnetic transducer.

[0060] The amplifier **20** is attached to the housing **16**, and includes an input member **32**, an output member **34**, and a transmission member **36**. The input member **32** is coupled to the vibration source **12** and the output member **34** is coupled to the transducer **18**. Specifically, the output member **34** is coupled to a moveable part of the transducer **18**, such as the first part **22**. In the example embodiments described herein, the amplifier **20** is described as being directly coupled to the housing **16**. Alternatively, the amplifier **20** may be coupled to the housing **16** via a part of the transducer that is fixed to the housing **16**. For example, if the second part **24** is fixed to the housing **16**, the amplifier **20** may be attached to the second part **24**, thereby being coupled to the housing **16** via the second part **24**.

[0061] The amplifier **20** receives a motion from the vibration source **12** via the input member **32**. More particularly, a motion generated by the vibration source **12** may move the input member **32** in a direction parallel with the central axis **26**. The transmission member **36** increases the amplitude of the motion received and transmits an amplified motion to the transducer **18** via the output member **34**. Specifically, the transmission member **36** increases the motion, such that the transducer **18**, in response to the output member **34**, moves a distance greater than the distance travelled by the input member **32** in response to the vibration source **12**. When the transducer **18** operates as an actuator, the amplifier **20** receives a motion from the transducer **18** via the output member **34**. After amplification, the amplifier transmits the motion to an external system via the input member **32**. The amplifier may amplify the displacement of the motion or the force of the motion.

[0062] While the amplifier **20** is described in relation to an electromagnetic transducer, other types of transducers may receive the amplified motion of the vibration source **12**. For example, if the transducer **18** is a piezoelectric transducer, one side of the structure can be fixed to the housing **16** and the other can be attached to the amplifier **20**. By increasing the amplitude of the motion, the amount of strain imposed on the piezoelectric material is increased. For an electrostatic transducer, by increasing the amplitude of the motion, a gap between electrodes or an overlapped area of an electrode surface is modified to increase the capacitance outputted. Thus, the amplifier **20** can be utilized for various suitable transducers that have at least one moving part.

[0063] The amplifier **20** primarily includes a mechanical configuration for increasing the amplitude of the motion from the vibration source **12**. For example, the amplifier **20** may include a gear configuration, a lever configuration, a linkage configuration, or a hydraulic configuration as described herein. Each configuration includes the input member **32** for receiving the motion from the vibration source **12**, the transmission member **36** for increasing the amplitude of the motion received, and the output member **34** for transmitting the amplified movement to the transducer **18**. Movement of the various components of the energy harvester **10** and the vibration source **12** may be described with reference to a coordinate system having three orthogonal axis (x, y, z), where the central axis **26** is parallel with the y-axis.

[0064] FIGS. **2-4** depict an example embodiment of a concentric gear amplifier **100** which can be used as the amplifier **20** in the energy harvester **10**. The concentric gear amplifier **100** includes an input rack **102**, an output rack **104**, and a gear assembly **106**. The concentric gear amplifier **100** is attached to the housing **16** via a frame **107**. The frame **107** may be attached to the housing **16** using various suitable methods, such as screws, bolts, welding, adhesive, etc. For purposes of clarity, portions of the input rack **102** and the output rack **104** are cut-off in FIGS. **2** and **3**.

[0065] As the input member **32**, the input rack **102** is coupled to the vibration source **12** at one end and interfaces with the gear assembly **106** at the other end. As the output member **34**, the output rack **104** interfaces with the gear assembly **106** at one end and couples to the transducer **18** at the other end. More particularly, the output rack **104** is coupled to the first part **22** (i.e., moveable part) of the transducer **18**. The input rack **102** and the output rack **104** have a bar shape body and include a series of teeth on one